

**New York State Water Resources Institute
Annual Technical Report
FY 2010**

Introduction

The Mission of the New York State Water Resources Institute (WRI) is to improve the management of water resources in New York State and the nation. As a federally and state mandated institution located at Cornell University, WRI is uniquely situated to access scientific and technical resources that are relevant to New York State's and the nation's water management needs. WRI collaborates with regional, state, and national partners to increase awareness of emerging water resources issues and to develop and assess new water management technologies and policies. WRI connects the water research and water management communities.

Collaboration with New York partners is undertaken in order to: 1) Build and maintain a broad, active network of water resources researchers and managers, 2) Bring together water researchers and water resources managers to address critical water resource problems, and 3) identify, adopt, develop and make available resources to improve information transfer on water resources management and technologies to educators, managers, and policy makers.

Research Program Introduction

The NYS WRI's FY10 competitive grants research program was conducted in partnership with the NYS Department of Environmental Conservation and the Hudson River Estuary Program (HREP). The specific areas of interest for the FY2010 grants program were: 1) Research that addresses key knowledge gaps or issues of emerging importance; 2) Projects that integrate technical, legal and social expertise to promote innovative, watershed management strategies; and 3) Development of novel methods for knowledge transfer that enhance the communication of scientific research to teachers, technical providers or to watershed communities. Projects were evaluated by a panel consisting of representatives of the US Geological Survey, the NYS Department of Environmental Conservation (DEC), and faculty from Cornell University. In total, five research projects were supported in FY10 through the competitive grants program with a total funding level of \$100,850 (\$53,838 USGS 104B, \$47,012 HREP). These projects included:

1. Rock snot in sick rivers: What are the environmental drivers controlling blooms of the invasive diatom *Didymosphenia geminata* in the Northeastern and Mid-Atlantic U.S.?, PI: Dr. David Richardson, SUNY New Paltz.
2. Hydrological characterization of Woodlawn Beach State Park: Implications for pathogens. PI: Dr. Charlotte Roehm, Buffalo State College SUNY.
3. Streamflow standards for streams of the Hudson River Valley and New York. PI: Dr. Mark Bain, Dept. of Natural Resources, Cornell University.
4. The New York State Master Watershed Steward Program: Building Capacity for Climate Change Adaptation. PI: Dr. Shorna Broussard and Dr. Allison Chatrchyan, Dept. of Natural Resources, Cornell University.
5. Quantifying the endocrine activating potential of New York State waters using steroid-responsive bioassays.. PI: Dr. Anthony Hay, Dept. of Microbiology, Cornell University.

Additionally, the NIWR system continues to include a project carried-over from FY2009, "Restoring access to American eel habitat in tributaries of the Hudson River Estuary". Some final sampling was done using NYS WRI funds in late spring of 2010, but the majority of work was completed between March 2009 and March 2010. The report for this project included here is the same report submitted in FY2009 Annual Report (We could not remove it from the automated system that generates the annual report).

Restoring access to American eel habitat in tributaries to the Hudson River Estuary: Identifying opportunities and implications for stream communities

Basic Information

Title:	Restoring access to American eel habitat in tributaries to the Hudson River Estuary: Identifying opportunities and implications for stream communities
Project Number:	2009NY118B
Start Date:	3/1/2009
End Date:	12/31/2010
Funding Source:	104B
Congressional District:	22
Research Category:	Biological Sciences
Focus Category:	Conservation, Ecology, Water Use
Descriptors:	None
Principal Investigators:	Catherine O'Reilly, Robert Schmidt

Publications

There are no publications.

WRI/HREP Grant 2009

Saw Kill Eel Project Report

Restoring access to American eel habitat in tributaries to the Hudson River Estuary: Identifying opportunities and implications for stream communities

Participants

Principal investigators: Dr. Catherine O'Reilly (Bard College) and Dr. Robert Schmidt (Simon's Rock College of Bard)

Collaborators: Dan Miller (Hudson River Estuary Program/DEC), Chris Bowser (Hudson River Estuary Program/DEC)

Statement of the problem and Research objectives

Populations of American eels (*Anguilla rostrata*) have been declining for several reasons, including loss of habitat (Haro et al. 2000). In the Hudson River estuary, access to upstream habitat is severely restricted by numerous small dams that act as barriers to many miles of viable habitat upstream. From our previous work on the Saw Kill, we know that eel ladders can provide effective passageway over barriers and increase access to upstream habitat. In order to continue effective restoration of the American eel population, we need to identify other tributaries that would be appropriate for restoration projects, which will require assessment of barriers, existing eel populations, and incoming glass eel migrations. We propose to work with high school and college students to assess 7 tributaries to the Hudson River to prioritize sites for restoration. Our objectives are to determine the numbers of incoming glass eels in the spring migration at various tributaries. This approach will both help identify tributaries that have high numbers of incoming eels, and will also engage students and citizen scientists.

Methods

Fyke nets

To help assess glass eel migration into Hudson River tributaries, we collected data on incoming glass eels from several tributaries using fyke nets. Each fyke net was primarily sampled by local citizen scientists or high school students, under supervision of DEC education staff Chris Bowser and Sarah Mount. College interns helped prepare the nets for deployment (Fig 1). Preparations began in fall and winter, with spring sampling commencing in 2010. This grant funded 4 fyke nets for new sites in addition to the sampling done at the Saw Kill, although through additional funding our sampling was expanded to 9 sites (Table 1). The fyke net sites ranged from Westchester to Greene County, and involved approximately 250 regular volunteers and 1200 participants in classroom and field programs directly related to the eel project. The full list of spring 2010 sites with volunteers is provided in Appendix 1.



Table 1. Location of the fyke nets in spring 2010.

Stream	County
Hannacroix Creek*	Greene
Saw Kill*	Dutchess
Black Creek*	Ulster
Crum Elbow Creek*	Dutchess
Fall Kill	Dutchess
Indian Brooke	Putnam
Furnace Brook	Westchester
Minnisceongo*	Rockland
Saw Mill	Westchester

* Funded by WRI grant

Artificial habitat collectors

In addition, we tested a simple device that could facilitate data collection in sites where a fyke net is not feasible. An alternative to fyke nets are artificial habitat collectors, which are plastic saucers with tufts of polyethylene split rope fiber that have been successful for sampling larvae of other eel species (Silberschneider et al. 2001). The advantage of these collectors is that they do not need to be sampled every day and can be much more easily placed in a variety of locations at one site. Artificial habitat collectors have the potential to expand outreach and education programs with high schools because they are cheap and simple to sample, and if effective, they could be used to sample glass eels in Hudson River, where fyke nets are ineffective. We conducted a comparison between the efficiency of glass eel capture by artificial habitat collectors vs fyke nets in the Saw Kill and south Tivoli Bay.

Eel passage

Dan Miller and other DEC fisheries staff have also designed a highly portably and adjustable eel passage device, based on the one currently used at the Saw Kill. The plan is to deploy this passage device at one of the sites this summer.

Principle findings and significance

Fyke nets

We have found that the fyke nets have provided useful information about the glass eel migration. Southern tributaries seem to have higher numbers of glass eels than more upstream tributaries. There is a lot of daily variation in catch, which is not easily attributed to environmental factors such as temperature, tides, or moon phase (Figs 2 and 3). The fyke net data from spring 2010 is still being collected and has not yet been compiled across all sites.

Artificial habitat collectors

We found that the artificial habitat collectors were successful at sampling glass eels in South Tivoli Bay. The habitat collectors indicated that there was some spatial variation in glass eel distribution in the bay. However, using the artificial collectors was more difficult than using the fyke net, requiring large field buckets and that participants be fairly strong. We concluded that while these can provide information about glass eel presence, they are not as informative or as easy to sample as the fyke nets.

Eel passage

We are using the data from the fyke nets to determine where to place the new eel passage device this summer.

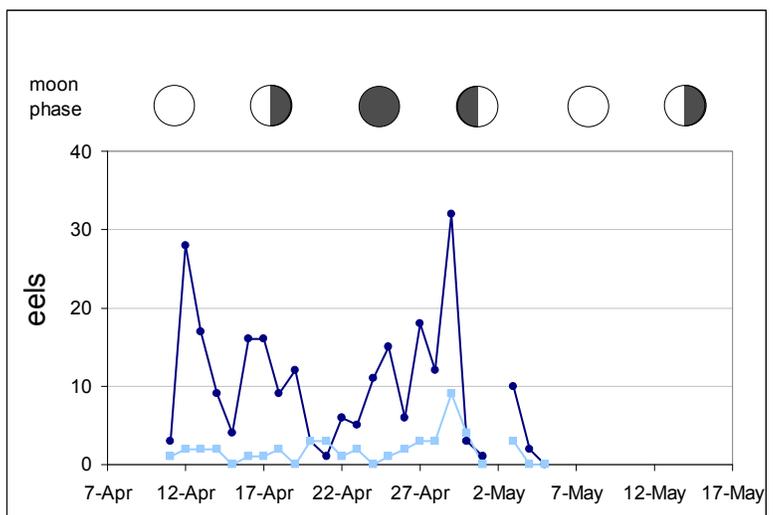


Fig 2. Glass eel (dark blue) and pigmented eel (light blue) catches in the Saw Kill fyke net in spring 2009. Moon phase is also shown.

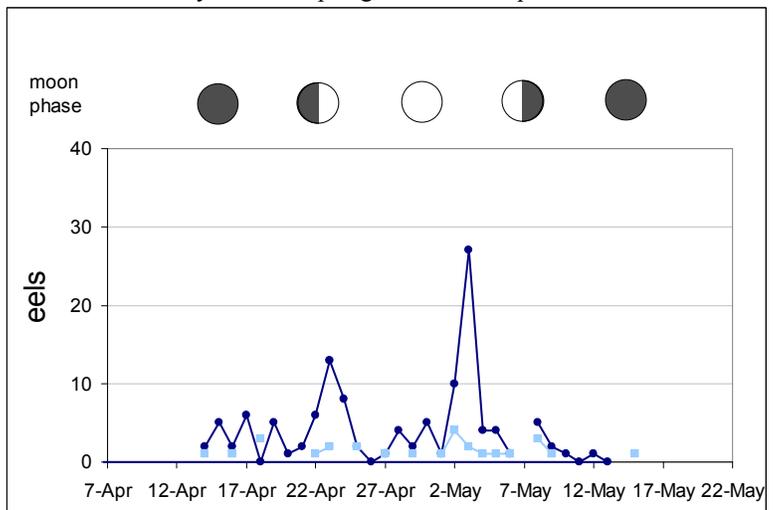


Fig 3. Glass eel (dark blue) and pigmented eel (light blue) catches in the Saw Kill fyke net in spring 2010. Moon phase is also shown.

Description of student support

Students from both high schools and colleges have been involved in sampling the fyke nets. The list below includes participants in spring 2010.

School districts: (total of around 200 students participated in field sampling)

- Ossining High School
- Poughkeepsie High School
- Arlington High School
- Coxsackie-Athens School District (high school and second graders)
- New Paltz High School
- Maple Wood High School
- Kingston High School
- Saunder's High School

Colleges

- Marist and Vassar College (10 students and staff)
- Bard College
Biology 202 Ecology and Evolution class participated in the fyke net sampling in 2009 and did the assessment of the artificial habitat collectors. (26 students)
A team of 9 students participated in the fyke net sampling in 2010. (9 students)
- Bard College at Simon's Rock
Bob Schmidt and 2 students sampled the eel ladder in summer 2009. (2 students)

In addition, several other community groups have been involved (Appendix 1).

Publications and presentations originating from the project

- Catherine O'Reilly and Chris Bowser have given several presentations to high schools and the general public about the project.
- We are also working on a new web site (eels.bard.edu) which is not yet complete. The goal of this web page is to have all the data from each site available, as well as background information about the project and about eels.
- There has also been media coverage in the Poughkeepsie Journal, April 11, the Catskill Daily Mail, May 21, and the Journal News, 25 May.

Description of other opportunities or collaborations that were enabled by the grant

- Additional funding was obtained TogetherGreen Fellowship Program of National Audubon and Toyota and Hudson River Valley Greenway (to Chris Bowser with Catherine O'Reilly as a mentor)
- This grant funded 5 sites for spring sampling using fyke nets. However, we were able to obtain additional funding to expand the network to a total of 9 sites.
- Sarah Mount, Bard College undergraduate, received a Polgar Fellowship to study eel-crayfish interactions. She found that eels and crayfish do not coexist in tributaries to the Hudson River. There were also no non-native crayfish in these tributaries. Her work suggests that eels may act as biocontrols for crayfish invasions.
- Jocelyn Edwards, Bard College undergraduate, conducted an analysis of eel passage on the Saw Kill, and found that eel passage data reflects incoming eel migration data with a time lag of 1 year.
- We are also beginning to think about formalizing the glass eel fyke net citizen science program and acquiring additional funding.

APPENDIX 1

2010 Eel Project of the New York State Department of Environmental Conservation

Hudson River Estuary Program

Hudson River National Estuarine Research Reserve

Bard College

Project Website: <http://www.dec.ny.gov/lands/49580.html>

Major Supporters

New York State Water Resources Institute at Cornell University

TogetherGreen Fellowship Program of National Audubon and Toyota

Hudson River Valley Greenway

Site Locations and Organizational Partners

Site: Fall Kill

Poughkeepsie, Dutchess County

Mid-Hudson Children's Museum

Poughkeepsie High School

Marist College

Arlington High School

Vassar College

Site: Crum Elbow Creek

Hyde Park, Dutchess County

Marist College

Hyde Park Landing

Vassar College

Site: Saw Kill

Annandale-on-Hudson, Dutchess Co.

Bard College

Site: Hannacroix Creek

New Baltimore, Greene County

Cornell Cooperative Ext. of Greene Co.

Soil & Water Cons. District of Greene Co.

New Baltimore Conservancy

Coxsackie-Athens School District

NYSDEC Five Rivers Environmental Center

Site: Indian Brook

Cold Spring, Putnam County

Constitution Marsh Audubon Sanctuary

Site: Minisceongo Creek

West Haverstraw, Rockland County

Mirant-Bowline

Strawtown Art Studios

Keep Rockland Beautiful

Rockland County Water Quality Committee

West Haverstraw Community Center

Site: Black Creek

Esopus, Ulster County

Scenic Hudson

Kingston High School

New Paltz Central School District

Marist College

Boy Scouts of America

Maple Ridge High School

Rondout Valley High School

Site: Furnace Brook

Cortlandt, Westchester County

Ossining High School

Putnam/Northern Westchester BOCES

Site: Saw Mill River

Yonkers, Westchester County

Greenburgh Nature Center

Groundwork Yonkers

Beczak Environmental Education Center

APPENDIX 2

Independent Research Poster by Jocelyn Edwards, Bard College undergraduate

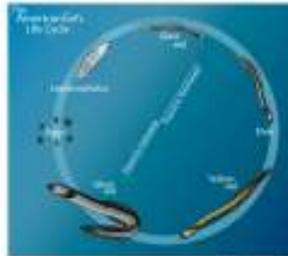
The American Eel: Population Growth and Decline In the Sawkill

A study by Jocelyn Edwards
Advisor, Catherine O'Reilly

Our Study:

Bard College has been collecting eel data from an eel ladder and a fyke net for the past four years. The eel ladder, located in the Saw Kill Stream, at the base of the dam, catches eels that are adults, large enough to make their way up the water fall. The fyke net, located in the estuary at the mouth of the Saw Kill, catches tiny glass eels, a few months old, who are making their way from the Atlantic to the Saw Kill. We have been counting and measuring the eels that have been using the ladder and the fyke net.

This data can show us how the population of American Eels has changed over the past four years.



Eel Life Cycle:

American eels are born in the Atlantic Ocean. For the first year of their lives, they are carried by ocean currents to rivers and bays such as the Hudson River. Here, they find small streams or inlets to travel up and make their long-term residence. As the eels get older, larger and stronger, they can travel further upstream, scaling treacherous waterfalls and other seemingly impossible feats. Once the eels have reached sexual maturity, they travel back to the Atlantic, mate, reproduce and die, leaving the baby 'glass eels' to be carried by the ocean currents back to the American rivers and streams.



The Fyke net of the mouth of the Sawkill

Glass Eels - Infant American Eels

Eel Ladder Data

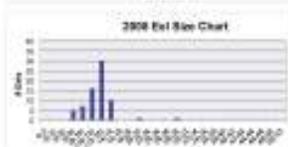
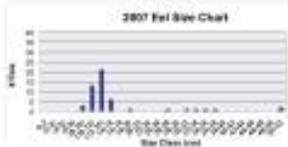
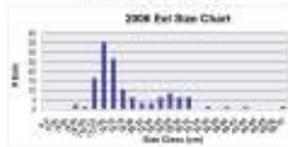


Fig. 1. Number and size (in 4.0 cm) of eels caught in the eel ladder from the years 2006-2009. The size classes go in 2 cm increments.

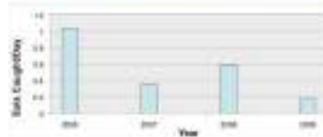


Fig. 2. The number of eels caught per day in the eel ladder has dramatically decreased since 2006.

The data from the eel ladder suggests that there has been an eel population decline since the year 2006. The number of eels caught per day for 2009 is six times smaller than the number in 2006. Since this data only deals with older eels, traveling further upstream, we must also look at the fyke net data.



The Eel Ladder at the base of the dam

A full grown American Eel

The decreased use of the eel ladder may be an effect of competition. Before the eel ladder was placed in the Saw Kill, the eels had no way of traveling higher than the dam, collecting below in a dense, highly competitive area. The ladder allowed eels to move upstream, reducing densities and competition below the dam. We suspect that the frequent use of the eel ladder in 2006 was an initial surge of eels that had been collecting below the dam for many years. The numbers of the subsequent years are low only in relation to the 2006 data.

Fyke Net Data

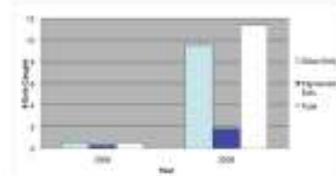


Fig. 3. There were many more glass eels caught in 2009 than in 2006. This suggests that the eel population is not on the decline at all, but increasing.

If it takes one to two years for an eel to grow to 12-14 centimeters (the length which they tend to use the eel ladder), we can assume that the eels being caught and recorded in the fyke net will not be observed in the eel ladder until one to two years later. If this is the case, the glass eels we recorded in the fyke net for the year 2006 are the same 12-14 inch eels using the eel ladder in 2008. Since the number of glass eels caught in the fyke net this year was high, we can predict that the number of eels using the eel ladder next year will be high (Fig. 4).



Figure 4

Conclusion: The eel population in the Saw Kill is increasing. Although the numbers of eels using the ladder has been decreasing, the number of eels using the fyke net is increasing. If our method of prediction is correct, we will see a lot of eel using the eel ladder next summer.

ers: What are the environmental drivers controlling blooms of the invasive diatom *Didymosphenia geminata* in the Northeastern and Mid-Atlantic U.S.?

Rock snot in sick rivers: What are the environmental drivers controlling blooms of the invasive diatom *Didymosphenia geminata* in the Northeastern and Mid-Atlantic U.S.?

Basic Information

Title:	Rock snot in sick rivers: What are the environmental drivers controlling blooms of the invasive diatom <i>Didymosphenia geminata</i> in the Northeastern and Mid-Atlantic U.S.?
Project Number:	2010NY134B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	22
Research Category:	Water Quality
Focus Category:	Invasive Species, Surface Water, None
Descriptors:	None
Principal Investigators:	David Richardson

Publications

1. Richardson, DC; Achterberg, LA; Redfield, MR; Root, SM; Arscott, DB; Gibson, C; Hoellein, TJ. 2011. Rock snot in a sick river: *Didymosphenia geminata* (Didymo) blooms and water chemistry in Esopus Creek, Catskill Mountains, NY. North American Benthological Society poster presentation, Providence, RI.
2. Root, SM; O'Reilly, CM. 2011. An assessment of three common decontamination products on the invasive diatom *Didymosphenia geminata* (Rock snot). North American Benthological Society poster presentation, Providence, RI.

WRI/HREP Grant 2010 Final Report

Title: Rock snot in sick rivers: What are the environmental drivers controlling blooms of the invasive diatom, *Didymosphenia geminata*, in the Northeast and Mid-Atlantic United States?

Participants

Principal investigators: Dr. David Richardson, SUNY New Paltz; Dr. Timothy Hollein, Loyola University; Dr. David Arscott, Stroud Water Research Center; Dr. Catherine Gibson, Skidmore College

Collaborator: Ms. Samantha Root, Bard College

Problem and Research Objectives

Over the past decade, the invasive algae species *Didymosphenia geminata*, commonly known as “didymo” or “rock snot,” has gained notoriety. Native to the Faroe Islands in Northern Europe, this freshwater diatom has now spread across North America, Asia, and New Zealand (Bergey et al. 2009, Kastovsky et al. 2010, Lyngbye 1819, Whitton et al. 2009). Through the reproduction of its sulfated mucopolysaccharide stalk (Fig. 1), this freshwater diatom is capable of forming extensive mats that grow up to eight inches thick and cover up to 100% of the substratum and stretch for miles downstream. These mats, often referred to as nuisance blooms, cause negative ecologic and economic impacts on the areas where they occur (Spaulding and Elwell 2007). In New Zealand, didymo nuisance blooms have caused hundreds of thousands of dollars in damage by clogging intake pipes and discouraging tourism to once renowned fly-fishing streams.

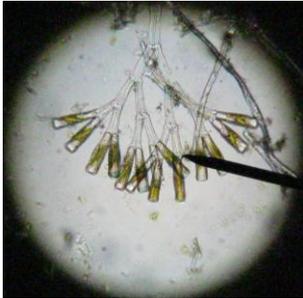


Fig.1. Didymo cells and stalks during rapid multiplication and growth in Rondout Creek, April 2011. Photo credit: Nathaniel Rigolino and Shaina Beirne.

Previous research has shown that there were similarities among streams didymo inhabited. Geographically, didymo seems to prefer montane and boreal rivers and streams (Kirkwood et al. 2007). Chemically, didymo was often found in cool to cold, oligotrophic (low-nutrient), water systems (Bergey et al. 2009, Kirkwood et al. 2007). Hydrologically, didymo was found in water with a moderate rate of flow (Kirkwood et al. 2007). Since these similarities apply to a broad spectrum of streams, it is important to determine more specific factors that seem to dictate the presence of didymo.

Our study was designed to determine the abiotic factors that affect the growth of the didymo bloom in the Esopus Creek in New York State. In 2009, didymo was confirmed downstream of the portal for the Shandaken Tunnel in the Esopus Creek. Since didymo was only seen downstream of the portal in 2009, it was assumed that the portal somehow controlled the growth of didymo. In June and July of 2010, we took weekly measurements of the physical and chemical parameters above and below the portal for the Shandaken Tunnel. The goal of our study was to figure determine conditions for didymo presence and growth to predict the future spread of the nuisance algae species to other streams.

Methods and Procedures

Site Description

Located in Ulster County, NY, the Esopus Creek is a tributary to the Hudson River and collects water from the east central Catskill Mountains. Approximately 20 km downstream from Winnisook Lake, Esopus headwaters, the Shandaken Tunnel empties into the Esopus – this site is called ‘the portal’. The tunnel is a 29 km aqueduct that drains water from the Schoharie Reservoir (Schoharie, Delaware, and Greene Counties). With this added water supply to the Esopus, there is increased discharge, width, and depth of the water downstream of the portal entrance. The presence of didymo in the Esopus was confirmed between the portal entrance and the Ashokan Reservoir 21 km downstream in 2009. Our study was conducted one year later, during June and July of 2010, between the headwaters and the Ashokan Reservoir. We had seven study sites total: three sites above the portal entrance and four sites below the portal entrance (Fig. 2). This particular section of the Esopus is popular for trout fishing, recreational tubing, kayaking, and swimming.

We collected biological, physical, and chemical parameters weekly at each of our study sites. We assessed didymo coverage using a didymo scale (Miller *et al.* 2009) that measured the extent of the bloom on a 0-10 rating scale and measured the percent coverage of didymo and other algae across a transect at each site (Gibson, personal communication, 2010). We performed didymo and other algae presence/absence readings based on visual and touch assessment: didymo was brown and had a wet cottony texture, whereas other algae species were generally green or brown and had a slippery feel to them (Gibson, personal communication, 2010). We also collected triplicate rock-scraping samples at each of our study sites and used those scrapings to measure areal coverage of ash-free dry mass, and chlorophyll a, b, c and phaeophytin. We measured water velocity, depth, discharge, and temperature at each site. Finally, we assessed water chemistry (conductivity, pH, total suspended solids (TSS), sodium, ammonium, potassium, magnesium, calcium, fluoride, chloride, nitrate, sulfate, and dissolved organic carbon).

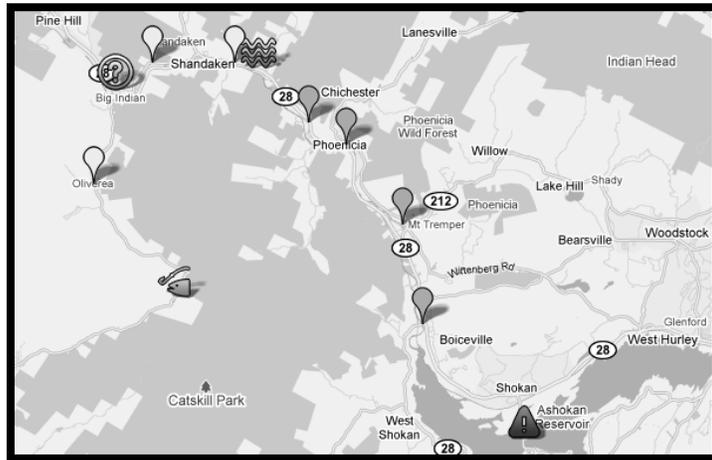


Fig. 2. Sample collection sites above (light grey markers) and below (dark grey) the Shandaken tunnel (curved lines).

Principle Findings and Significance

Bloom Characteristics

With the exception of the site closest to the headwaters (Up1), which never had any didymo present, the didymo coverage at each study site was variable over the one-month study period. Didymo coverage increased with increasing distance from the headwaters (Fig. 3). The portal also had an effect on the amount of didymo present. The didymo coverage (% didymo, dry mass and ash free dry mass on the stream bottom) was higher below the portal than above the portal (Not pictured, t-tests, $p < 0.05$).

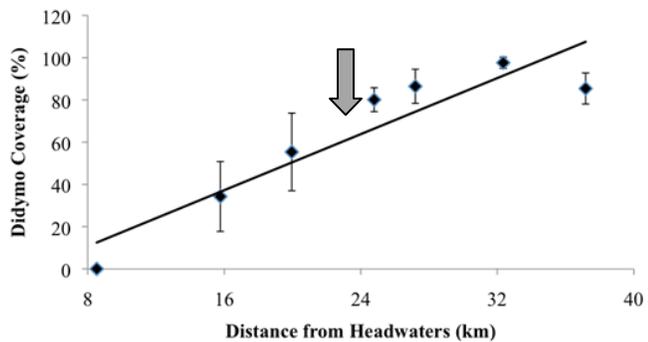


Fig. 3. The percent didymo coverage increased with increasing distance ($F_{1,5} = 30.39$, $p = 0.0027$, $R^2 = 0.83$). Grey arrow indicates the portal location. Error bars represent standard error.

Stream Characteristics

The distance from the headwaters affected certain factors. Temperature and pH increased linearly from upstream to downstream. The portal increased Esopus Creek water velocity, discharge, DOC concentration, and TSS concentration. The characteristics of water chemistry were different from the one site where didymo was present to all other sites. Conductivity was significantly lower at the site closest to the headwaters, where didymo was absent, compared to the sites farther downstream (Fig. 4 top; $F_{6,21} = 16.8$, $p < 0.001$). However, nitrate was significantly higher at the site closest to the headwaters, where didymo was absent, compared to the sites farther downstream (Fig. 4 bottom; $F_{6,21} = 20.7$, $p < 0.0001$). Phosphate and sulfate concentrations were higher downstream than at the upstream site where didymo was absent but were not significantly different because of high temporal variability at several downstream sites.

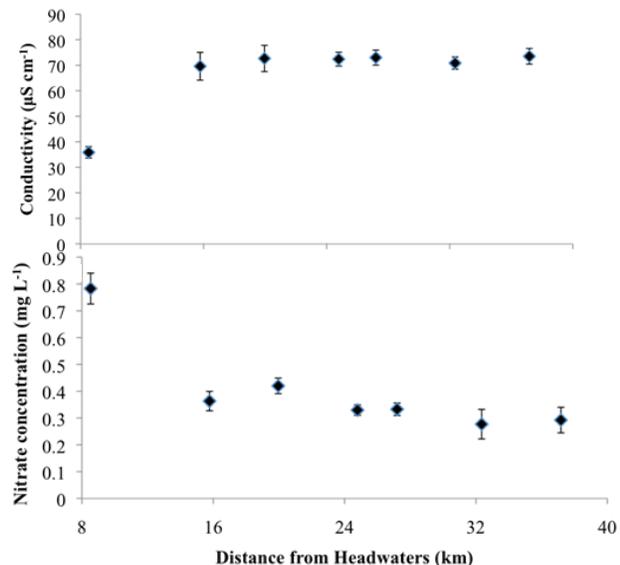


Fig. 4. The conductivity (top) and nitrate concentrations (bottom) were significantly different at the site closest to the headwaters, where didymo was absent, compared to the sites further downstream. Error bars represent standard

Discussion

Didymo clearly expanded to new sites in New York State in 2010. In the Esopus Creek, our study was the first to confirm the presence of didymo at two sites above the portal for the Shandaken Tunnel. Although didymo was not visible at these sites during the first week of sampling, we confirmed its presence using microscopic analyses of rock scrapings. This was also the first summer that didymo was found in another New York State stream, Kayaderosseras Creek near Saratoga Springs and this spring, March 2011, didymo was found in Rondout Creek below the Rondout reservoir, another stream and reservoir system in the Catskills. We are currently monitoring the water chemistry and bloom characteristics in this creek.

In Esopus Creek from the headwaters to the Ashokan Reservoir, didymo growth increased in a downstream direction in the Esopus Creek (Fig. 2). We found more didymo coverage downstream of the portal compared to upstream. However, since we confirmed the presence of the invasive algae species above the portal, we ruled out the portal as a controlling factor of didymo growth. Rather, the increased presence downstream of the portal was most likely due to didymo overwintering in that area over the previous year.

In our observations, however, we determined that substrate size and material were not controlling didymo growth. Previously thought to primarily attach to rocky, coarse substrate (Canter-Lund and Lund 1995, Lindström and Skulberg 2008), we found that didymo did not have much of a preference in the type substrata it inhabited. In the Esopus Creek, we observed didymo stuck to rocks that ranged in size from pebbles to boulders. In two other New York streams, the Kayaderosseras Creek and the Battenkill Creek, we observed didymo growing on sand and other novel substrate like aluminum cans, baseball caps, and bicycle tires that were littering the streams. Additionally, our observations suggested that velocity is also not a controlling factor of didymo growth. Unlike previous research (Kirkwood et al. 2007, 2008), which found a negative relationship between didymo biomass and discharge, we saw didymo growth at all rates of flow up to 1.5 m s^{-1} . The thickest parts of the didymo bloom were in the sections of the stream with the highest rate of flow.

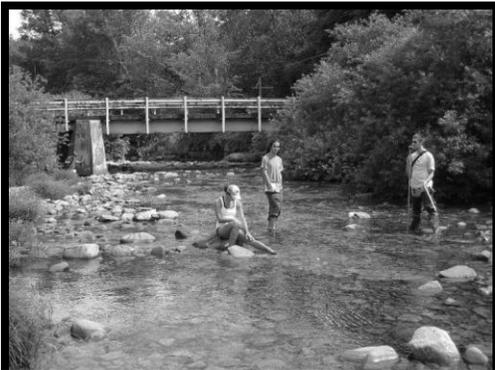


Fig. 5. Upstream site in Esopus Creek with no fishing access and no didymo.

Our first sampling site (Fig. 5) was the furthest up the mountain and it had clear, cool waters, an approximately twenty-foot width, and no more than a twelve-inch depth. It was clearly not being used as a fishing access site, so it was not clear if didymo had been transported to that location. Even if didymo had been transported, the water chemistry was different from that site to sites with didymo. Sites with didymo had higher conductivity, higher sulfate, higher phosphate, higher pH, and lower nitrate. Initially results from an experimental assay indicate that sulfate and phosphate increase didymo stalk production, while nitrogen species could inhibit

didymo production or provide nutrients for other competing algae. The areas where didymo was present were wider, deeper sections of the stream that were used for fishing.

In predicting the susceptibility a site has for a didymo invasion, the likelihood of the actual introduction of the nuisance algae species from human is likely more important than any other factor. However, water chemistry may control the establishment of didymo or the size of bloom after it has been introduced.

Since the introduction of cells is critical the location of didymo bloom, we decided to help inform different contingents of people who might use the stream (e.g. fishermen, scientists, or other recreationalists like tubers) on how to identify didymo and decontaminate their equipment before moving from stream to stream. We decided to take three approaches to informing the general public about the transport of didymo. First, we established a facebook page (NYS Didymo (Rock Snot) Research) and email (nysdidymo@gmail.com) to establish contact with the general public, inform them of current research on an up-to-date research. Already, the facebook page has been ‘liked’ by over 100 people and we have been contacted by several local organizations for more information. Second, we have given talks and presentations to a range of audiences including scientific and community groups. Several of the talks that Ms. Samantha Root has given to local trout and fly-fishing organizations has revealed that local fishermen are either unaware of the didymo problem or need advice on the best way to clean boots and equipment to eliminate transfer. For example, our suggestion is to soak equipment in 2% bleach and dry it completely. Also, we suggest avoiding felt-soled waders – they seem to allow the cells to live the longest and have been banned in Maryland, Vermont, and Alaska as of this year. Finally, we designed, printed, and disseminated cards and posters that inform about the didymo problem, provide advice on indentifying didymo, and give suggestions on how to decontaminate equipment (Fig. 6). We have already passed these out at our presentations, given them to the DEC and local community groups, and plan to distribute them to local businesses around the Catskills.



Fig. 6. Front and back of wallet size cards for didymo identification and decon.

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Hydrological characterization of Woodlawn Beach State Park: Implications for pathogens

Basic Information

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Publications

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Hydrological characterization of Woodlawn Beach State Park: Implications for pathogens.Charlotte Roehm¹, Stephen Vermette¹ and Meg Janis²¹ Buffalo State College, SUNY² New York State Office of Parks, Recreation, and Historic Preservation**1. Problem Statement and Research Objectives**

The role of hydrological forcings in structuring wetlands has been recognized (*Bedford, 1992; Trebitz et al., 2002*). However, a detailed understanding of the hydrologic controls on wetland structure and function is needed in order to guarantee better protection and restoration initiatives. Wetlands are now widely recognized for the value and services they provide, such as critical species habitats, protection against floods, water purification, amenities and recreational opportunities (*Mitsch and Gosselink, 2007*). In addition, coastal wetlands act as transitional zones between upland terrestrial and aquatic ecosystems and are often found adjacent to beaches. The economy of many coastal areas is dependent on the recreational value of these habitats (*USGS, 2009*). Degradation of these environments is often associated with human activity and results in the alteration of natural processes that otherwise define critical ecosystem functions and values. Wetlands may be, however, the most cost effective method to decrease non-point pollutants, often the principal contributor of *E. coli*. Remediation and re-engineering of 'natural' wetlands may improve their purification functions (*Mays and Edwards, 2001*).

Beach closures resulting from high levels of pathogens and contaminants along the Great Lakes coast lines are common (*Natural Resources Defense Council, 2009*). The number of 2008 closing and advisory days at ocean, bay and Great Lakes beaches topped 20,000 attesting that our nation's beaches continue to suffer from serious water pollution problems (*Dorfamn and Rosselot, 2009*) (*Natural Resources Defense Council, 2009*). Many Great Lakes coastal communities have adopted beach monitoring programs to protect visitors from exposure to potentially harmful bacteria and pollutants in accordance with the requirements of the U.S. Environmental Protection Agency (EPA) (*Beaches Environmental Assessment and Coastal Health Act, 2000*). These monitoring programs, however, do not target the core of the problem and often result in preempted decisions that are based on simple empirical relationships (*Lis, 2007*). Alternative, cost effective approaches to reduce pathogen transport and pollutant contamination in nearshore and beach environments of the Great Lakes may be found through coastal wetland protection and restoration measures. It is well recognized now that both nearshore and foreshore environments are critical source areas for pathogens (*Whitman et al., 2003; Ishii et al., 2007*). However, the hydrologic dynamics that may affect pathogen transport and redistribution are still poorly understood. The presence of wetlands adjacent to such areas may provide a potential hydrologic connection to alternative transport mechanisms as well as important if not vital sink areas for pathogen and pollutant inactivation and immobilization. Reduced loads of total suspended sediments, nitrate, and pathogens such as *E. coli* of between 60 and 80% have been observed in natural wetlands (*Knox et al., 2008*). External hydrologic forcings such as seiches can play an important role in providing surface water to adjacent coastal wetlands through both flushing and inflow (*Trebitz et al., 2002*) and, therefore, afford a redistribution mechanism.

Superposed on the surface water connectivity is the complex interaction with groundwater flowpaths. This level of complexity necessitates a sound understanding of hydrologic characteristics in order to commit to effective management of water resources (Winter, 1999). Few studies have addressed the surface and groundwater hydrologic characteristics of coastal wetlands and their potential roles as exchange pathways which may be responsible for spatial and temporal uncoupling between pathogen and pollution source and exposure. No hydrologic studies have been made at Woodlawn Beach State Park to date. Woodlawn Beach State Park in Erie County, N.Y. remained closed to beachgoers for 98% of the 2009 summer and saw the highest exceedance of pathogen counts (34%) of all Lake Erie beaches (Dorfamn and Rosselot, 2009). Restoration initiatives prompted by the New York State Office of Parks, Recreation, and Historic Preservation are underway to address these issues and to improve the quality of both water resources and ecosystem functions.

1.1 Goals:

This project provides results for two focal but complementary areas:

- i) Hydrology and water cycle dynamics of Woodlawn Beach State Park
- ii) The spatial and temporal variability and potential transport pathways of *E. coli*.

Currently, the Woodlawn Beach State Park uses the NOWCAST model to predict the likelihood of high lake water *E. coli* counts based on rainfall events of >0.5 inches in 24 hours. This results in many pre-emptive beach closures. There is, however, a need for more accurate methods of evaluation (Nevers *et al.*, 2009). Recommendations called for either a stricter 'one quarter inch' rule or for beach specific studies to consider other controlling factors. This instigates a much higher level of complexity of the ecosystem dynamics than previously thought. Further, the geographical location of this Park - the narrowing of the Lakes eastern basin - necessitates that surface and subsurface hydrological exchanges between the wetland and the lake water may be affected by seiches. These events can provide alternative pathways for translocation of pollutants and pathogens between lake waters and wetlands. The transport to wetlands entails potential immobilization, thus lowering lake water and foreshore concentrations.

A detailed knowledge of the hydrology and cycling of water and the spatial and temporal variability of *E. coli* at Woodlawn Beach State Park will improve predictive models for pathogen and pollutant transport, frequency, and hotspot dynamics. The results of this study will provide essential information required for upcoming restoration initiatives at Woodlawn Beach State Park to improve both the water quality and the ecosystem's capacity to perform critical ecological functions.

1.2 Scope:

The goal of this project is to provide New York State Office of Parks, Recreation, and Historic Preservation with detailed information of the hydrologic characteristics and seasonal dynamics of the Woodlawn Beach State Park as well as guidelines concerning restoration strategies used to improve water quality and ecosystem function. This study specifically addresses the mission of the Hudson River Estuary Program through helping to conserve and restore the natural and unique resources of wetlands and the coastal regions of the Great Lakes; by promoting full public use and enjoyment of the lake and the adjacent beaches and wetlands; and by providing

effective strategies for cleaning up the pollution that currently affects our ability to use and enjoy these resources.

1.3 Objectives:

The objectives of this research are:

1. To map the surface and groundwater hydrology and calculate the water budget of Woodlawn Beach State Park.
2. To determine hydrological exchanges between lake water and wetlands and quantify their potential role in transporting and redistributing *E. coli* (and other pathogens and pollutants) within the ecosystem complex.
3. To identify the potential role wetlands play in reducing *E. coli* contamination on beaches of the Great Lakes, and as a result provide an informed management decision making process regarding restoration initiatives.

2. Methods and Procedures

A nest of piezometers and wells were installed in parallel transects running East to West from the upland to the lake in order to determine hydrological head and flow direction. A number of these piezometers were selected for sampling water chemistry, isotopes ($\delta^{18}\text{O}$ and $\delta^2\text{H}$) and *E. coli*. Isotopes will be used to determine the source and mixing of water at each sampling location. Water table level loggers (Odyssey) were installed permanently in order to determine temporal fluctuations in water level in the open wetlands. Pump tests were performed to determine the hydraulic conductivity of the soils.

Nearly daily measurements of dissolved oxygen, pH, turbidity, temperature and conductivity were measured at the inflow, outflow and at each open water wetland site. Additional spot measurements were made weekly throughout the creek.

Soil cores were taken at selected locations in system complex in order to determine sediment/soil structure, particle size distribution, porosity, water content, bulk density and organic matter content. Facilities for the latter measurements are currently available in the Watershed Laboratory at Buffalo State including a muffle furnace oven, a set of hydrometers and Orion weighing scales.

A small meteorological tower will be installed in the wetland area in order to measure atmospheric parameters that will be used to calculate the water budget of the complex. Photosynthetically active radiation (PAR), temperature, relative humidity (RH), wind speed and direction will be recorded. In order to better constrain the evaporation component a suite of Hobo (U10-003 & U22-001) temperature loggers will be distributed on the surface of the complex and at several location within the surface water of the wetland. These data will be then compared to site averaged evaporation rates measured with the use of an evaporation simulator (ETgage). This data will be used in combination with isotopic analysis to track specific

hydrological flow paths and to determine potential hotspots for *E. coli*. All other equipment is already available at Buffalo State College.

Field samples collected for analysis will be processed in the Department of Geography and Planning's Water Quality Lab and the Great Lake Center's Watershed Lab. The Water Quality Lab includes colorimeters and numerous meters and kits to analyze a suite of metals, nutrients, bacteria, and other conventional parameters. Isotope determinations in water samples were measured at the Cornell Isotope Laboratory (COIL).

3. Principle Findings and Significance

This project involved the work of 2 Masters students and one Undergraduate. Thomas Reeverts is working on his thesis with Dr. Roehm with a focus to create a combined dynamic hydrologic and *E. Coli* model that will be used to inform management at the Park. Joseph Petre is working with Dr. Vermette on a thesis focusing on the evaporation component of the Hydrologic budget. Andrew Pancykowski, worked as an undergraduate research assistant during the summer, helping to collect samples in the field, processing in the lab, as well as detailing some of the history of the area and potential identification of sources of *E. Coli* upstream of the complex. Both Thomas Reeverts and Joseph Petre presented their preliminary findings at the annual Rochester Academy of Sciences. As part of the initiative a display was set up in the Park's interpretive center, and we had several excursions of schools students to visit our research site and show the sampling strategies.

The initial results of the project have translated into several informed discussions with NY State Parks, Recreation and Historic Preservation concerning the future management of the wetland area. Recommendations include diverting the eastern section of the creek into Wetland B in order to increase the amount of water flowing through the wetland, decrease the flow rate (increase exposure) and to increase the potential for sedimentation. A possible extension of the wetland to the south, where wetlands B and C join (Fig. 1 & 2). In addition, it was recommended that the base-flow height of the water level in the creek and the wetlands be maintained higher than current low-flow. This will allow for a slower flow and increased exposure. However, it was cautioned that this level should not exceed 1.3 meters in the outflow section of the creek (Fig. 2), since high water table levels throughout the complex were found to a) allow for sub-surface water seepage from Wetlands A and C through the sand and onto the beach, and b) given the potential build up of water during high intensity precipitation events, the back-up of the creek resulted in the flooding of the main highway #5 to the East of the wetland. It was, however, also recommended that fluctuating dynamics should also be maintained in order to maximize potential re-oxygenation to the surface waters. Consultation has been made with the Department of Transportation to assure a safe level. Thomas Reeverts, a Masters student who is working on his thesis with Dr. Roehm, is preparing a combined hydrologic and *E. Coli* model that will address both these issues and that will be presented to the managers of the Park as a proposal for effective hydrologic control of *E. Coli* management at Woodlawn Beach State Park.

This project has resulted in several interesting outcomes related to the hydrologic dynamics of wetlands connected to Lake Erie. It has shown a significant interaction between Blasdell Creek flow and the wetlands as well as with the lake through influences of seiches. These dynamics are directly impacting the suitability of the wetland to act as a filter for *E. coli* and other nutrients

and metals. The study also shows that in fact the wetland complex can be divided into three distinct wetlands, each with unique vegetation, sediment morphologies and hydrologic dynamics (Fig.1).

The wetland complex has a soil that is characterized in part by slag due to the former industrial character of the surrounding landscape. The depth of the wetland was found to be significantly shallower than expected, with a combination of organic silt and sand mixtures to a depth of 40 to 60 cm maximum, overlaying a clay layer in Wetlands B and C. Wetland B is dominated by willows and purple loosestrife. The open water portion is also abundant in *Lemna minor* throughout the summer. The north-western arm of Wetland C was characterized by a deeper organic horizon (1.5 m) with a combination of marsh cattail and bulrush vegetation including *Typha latifolia* and *Phragmites australis* (delineating the predominant wet/drier transition zone). This was similar to Wetland A, which is characterized by open water setting with abundant *Typha*. The morphological setting of these wetlands and their dominant soil types, would lead one to believe that Wetland A would have lower soil *E. Coli* counts than Wetlands B and C. *E. coli* cells are significantly adsorbed to the clay fraction of the soil, while the organic matter content does not play a significant role. However, despite the existence of different factors that enhance bacterial cells retention, a high percent of *E. coli* cells is transported through soil media (Naclerio et al., 2009). Our results supported these findings, but in addition, we found that there was a greater exchange of *E. Coli* colonies between the mineral and organic soils. This has important implications since it would indicate that the organic soils in Wetlands B and C can be quickly replenished and flushed over the long term.

It was observed that the dominance of vegetation type and amount of insolation was related to *E. Coli* numbers measured in the surface water as has been previously found in the literature. Several previous studies have found that numbers of *E. coli* were higher in the presence of floating *Lemna spp* and declined significantly when floating *Lemna spp.* plants were removed to create open water areas. It is suggested that *E. coli* declined immediately after *Lemna spp* removal due to the increase in natural UV attenuation (McIntyre et al., 2006). In addition, the authors observed a steady build-up of *E. Coli* colonies in *Lemna* dominated waters by providing favorable attachment sites for the *E. Coli* and, hence, it was not allowing for effective free exchange of oxygen from surface winds to the water column. Similar results were observed in this study, whereby oxygen levels in Wetland B and to some degree in Wetland C became completely anoxic through a large part of the summer (data not shown). Due to the slower flowing nature of this site, renewal through water fluctuations was not induced.

The hydrologic dynamics between the wetland, creek and lake have proven to be very interesting. In this report we present a snapshot of a month where the dynamics can be followed over time. A suite of 7 water level sensors were placed in strategic locations that represent the different basins that, we hypothesized, would respond differently to storm and seiche events (Fig. 2). The data presented in Figures 3-6 have been composited so that the details can be outlined. It is our hope to incorporate these dynamics (following regression analysis) into the combined hydrologic and *E. Coli* model we are working on.

A couple of specific events that took place in the month of June will be discussed (See Fig. 6 for closer details of the hydrograph). There is a tight relationship between precipitation events and flow in the system, indicating that the system is fast responding and dynamic despite the

presence of wetlands. June 6th saw a large event happen with precipitation increasing to a peak rate of 0.5 inches per hour and resulted in over 3 inches of rain in the period of 5 hours starting mid-morning (Fig. 3). This event resulted in a rapid increase in water levels in the wetland complex and in the stream. However, when looking at Fig. 6a in more detail, it is evident that there is an initial first and most dramatic increase in water level occurring at the Outflow site of Blasdel Creek (> 500 mm increase in absolute level) and it was immediately transposed into Wetland A (~400 mm) and Wetland C (~500 mm). The Inflow gage also increased but the overall amount of increase was significantly smaller (~320 mm) and peaked nearly 10 minutes after the Outflow and Wetland A levels. A large increase in water level was also noted at Wetland C, which peaked slightly before the In Wetland B, Wetland B and out Wetland B sites (all ~ 350 mm). Following the peak water levels, the Outflow and Wetland A drained rapidly, followed by a slightly lower rate in the Inflow and Wetland C. The Wetland B sites, drained much more slowly and remained substantially higher relative to the initial pre-storm levels.

The interpretation of this event can be facilitated by integrating hourly data acquired from the local USGS Buffalo gaging station regarding Lake Erie water levels, wind speed and wind direction (Fig. 5a, b and c). A closer look at the data for this time period indicates that there was a substantial increase in lake water level of 1000 mm that was coupled to a rapid increase in wind speed (from 2 to 11 m s⁻¹) and a wind direction starting at ~320° and then sustained at 240° for several hours. These data are a clear indication of a seiche event. This falls in line with the observation of the water levels in the wetland and creek complex, indicating that the Outflow, Wetland A and Wetland C sites were influenced in most part by a reverse flow up the creek and into the wetland, with a delayed response in streamflow downstream from the Inflow and into the Wetland B area. Figure 7 represents a conceptual visualization of water flowpaths in the wetland complex as a result of this storm.

The implications this storm (and others observed throughout the summer) for *E. Coli* populations, indicated that indeed the number of colonies was often abated as the water was diverted through the wetlands from the main stream (Fig. 4). During this June 6th storm, colony numbers were seem to decrease by nearly 50% relative to the inflow, when measurements were made several hours following the end of the storm. However, with low numbers of *E. Coli* (>300) no difference was observed between in the inflow and outflow (Fig. 4) during most of the sampling year. This has implications for water level management, since high flow events that increase the water enough to divert the stream through the wetland, indicate a decrease in *E. Coli* colonies.

The example of the storm from the 17th of June would indicate a delayed combination of seiche lake effects, with an initial response to the storm observed in the Inflow and Outflow (Fig. 3 & 6). A large spike was observed in the In Wetland B site indicating that water was transferred from the creek to the wetland. However, about an hour following the peak rainfall event, the Outflow and Wetland A continued to increase in water level height, while the other sites remained constant or continued to decrease. Looking at the data from the USGS, it does not appear that there was any substantial wind event nor increase in lake water level. This would indicate that Wetland A was absorbing a large part of the water flowing downstream due to its higher connectivity to the creek. A cut-off level between Wetlands B and C and the creek is quite obvious at lower flow. The event noted on the 23rd of June was very similar to that described for the 6th of June, with a rapid increase observed in the Outflow and Wetland A initially, followed

by the other sites. High winds (~12 m s⁻¹) sustained by wind directions from the SW and W resulted in a seiche event that increased relative lake water levels by 600 mm. These results support previous findings about the potential impact of seiches on coastal wetland hydrology (Trebitz *et al.*, 2002).

Isotopic analysis of groundwater and surface waters along with chloride tracers are yet to be analyzed in detail. We believe these data along with piezometric heads and *E. Coli* colony numbers will help further elucidate the role of these wetlands for *E. Coli* abatement. To date the results indicate that seiche events, may indeed improve the abatement efficiency of this complex, through redistributing water into areas that stimulate either sedimentation or die-off of *E. Coli* colonies. The dynamic character of the hydrology of this complex, denotes an increased complexity that needs to be incorporated into management plans. It is hoped that the modeling effort will aid in attaining this goal.

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Figure Captions:

- Figure 1.** a. Woodlawn Beach location.
b. Subdivision of Woodlawn Beach wetland complex into three distinct wetland areas and Blasdell Creek.
- Figure 2.** Location of the seven water level loggers and the 30 piezometers nests for the hydrological characterization.
- Figure 3.** Example of water level changes at the seven gaging stations and rainfall events measured at the wetland meteorological station during the month of June 2010.
- Figure 4.** Escheria Coli colony counts measured daily at the inflow and outflow stations throughout the month of June.
- Figure 5.** USGS data from station 9063020 Buffalo NY for June 2010
a. Hourly water levels (m)
b. Hourly wind speeds ($m s^{-1}$)
c. Hourly wind directions ($^{\circ}$)'
- Figure 6.** Snapshots of events taken from Figure 3.
a. June 6th
b. June 17th
c. June 23rd
d. June 28th
- Figure 7.** Conceptual representation of major water flowpaths during the June 6th event

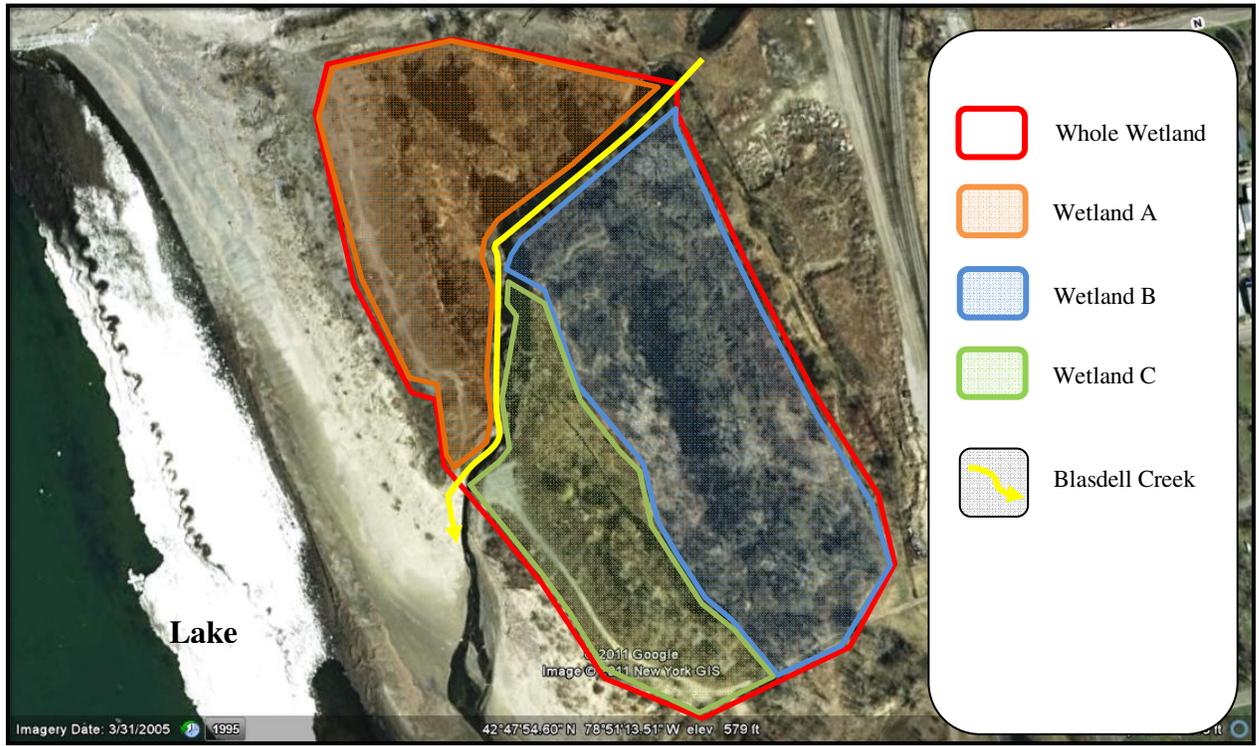


Figure 1.

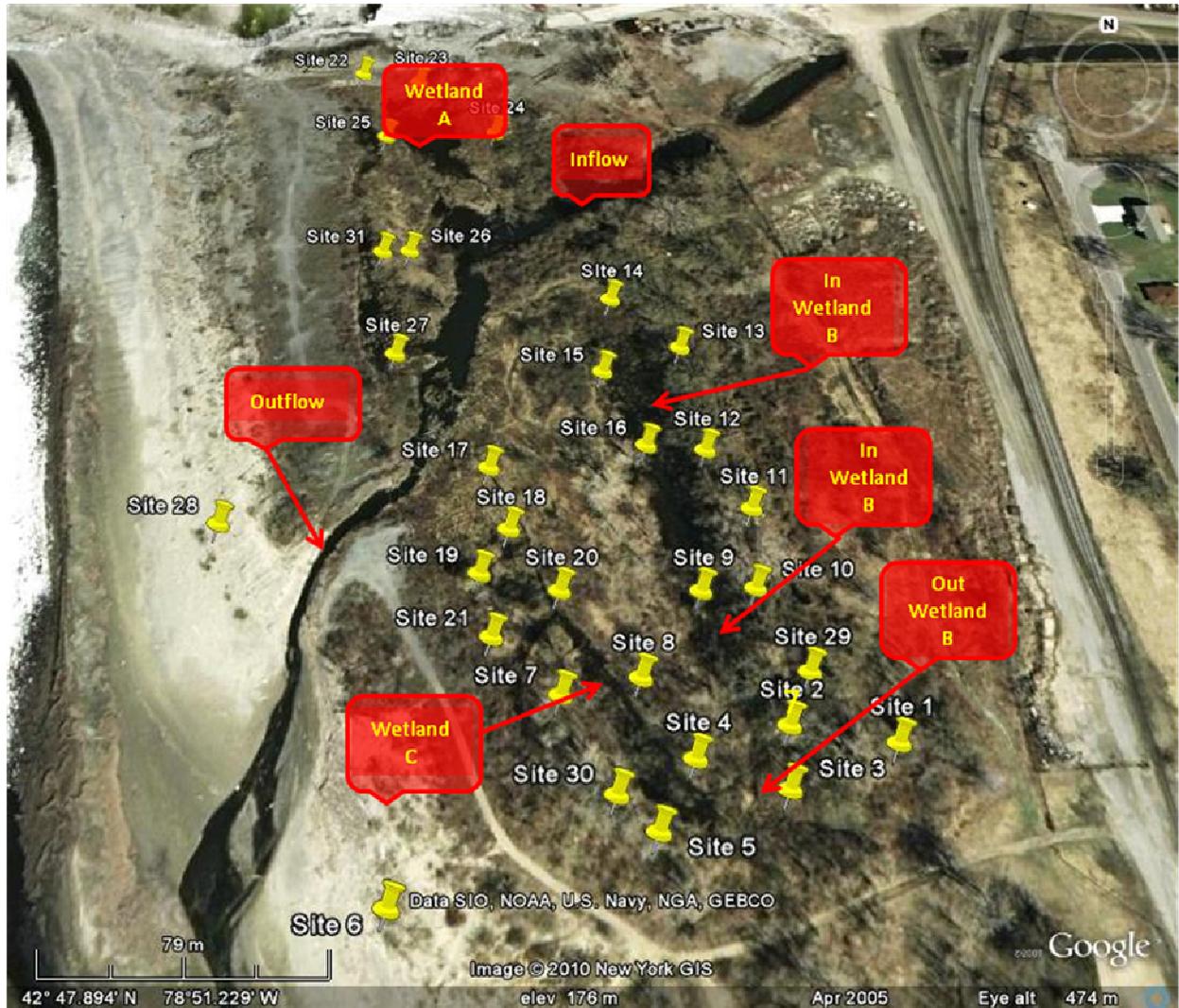


Figure 2.

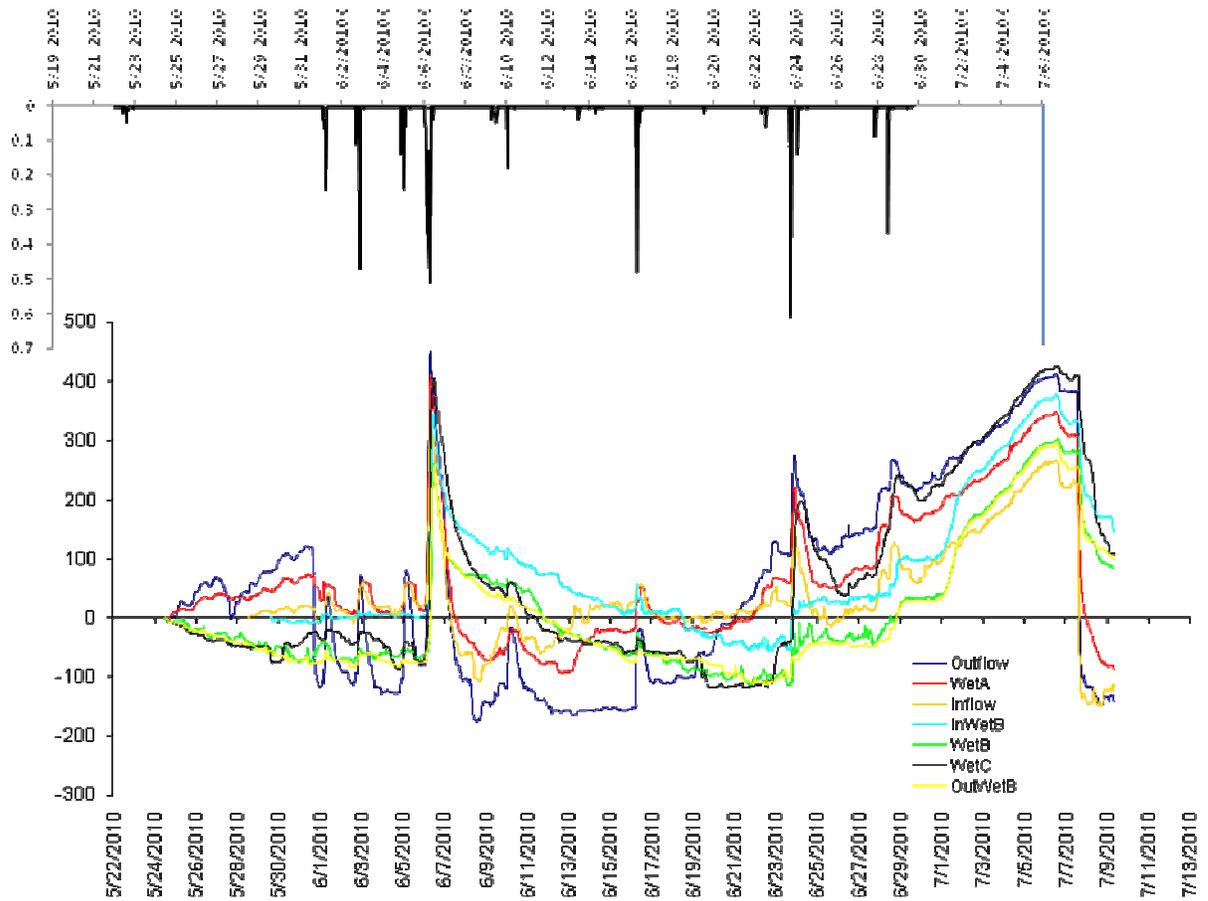


Figure 3.

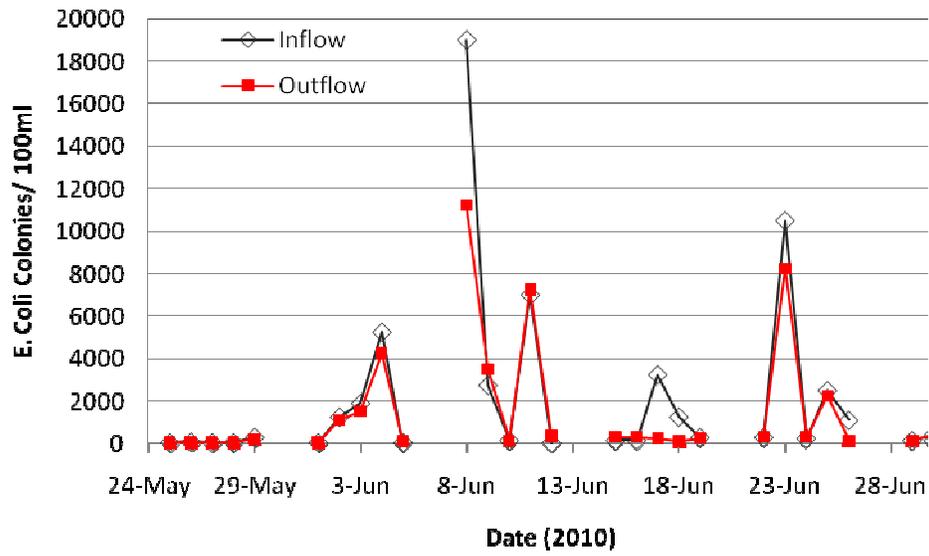


Figure 4.

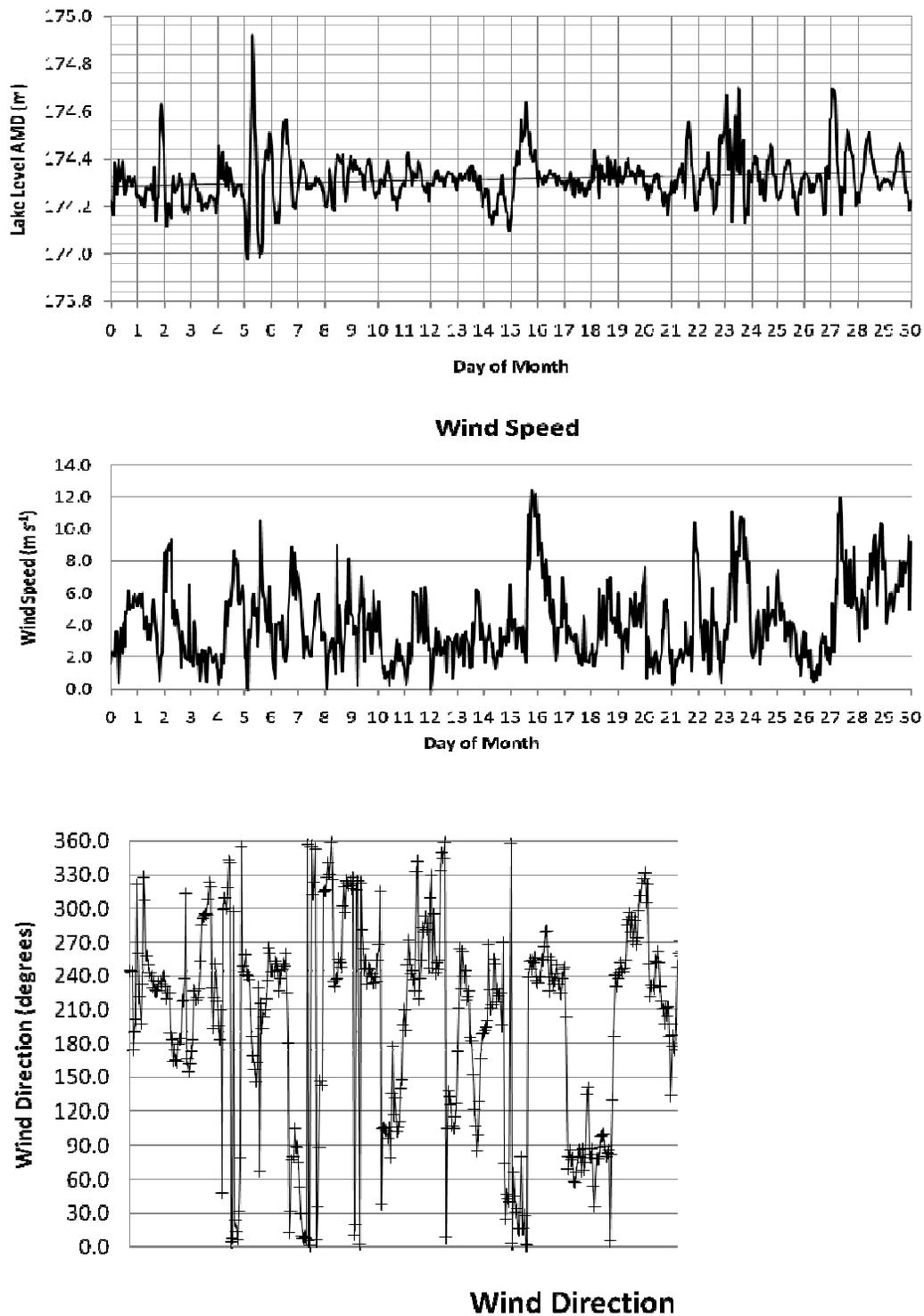


Figure 5.

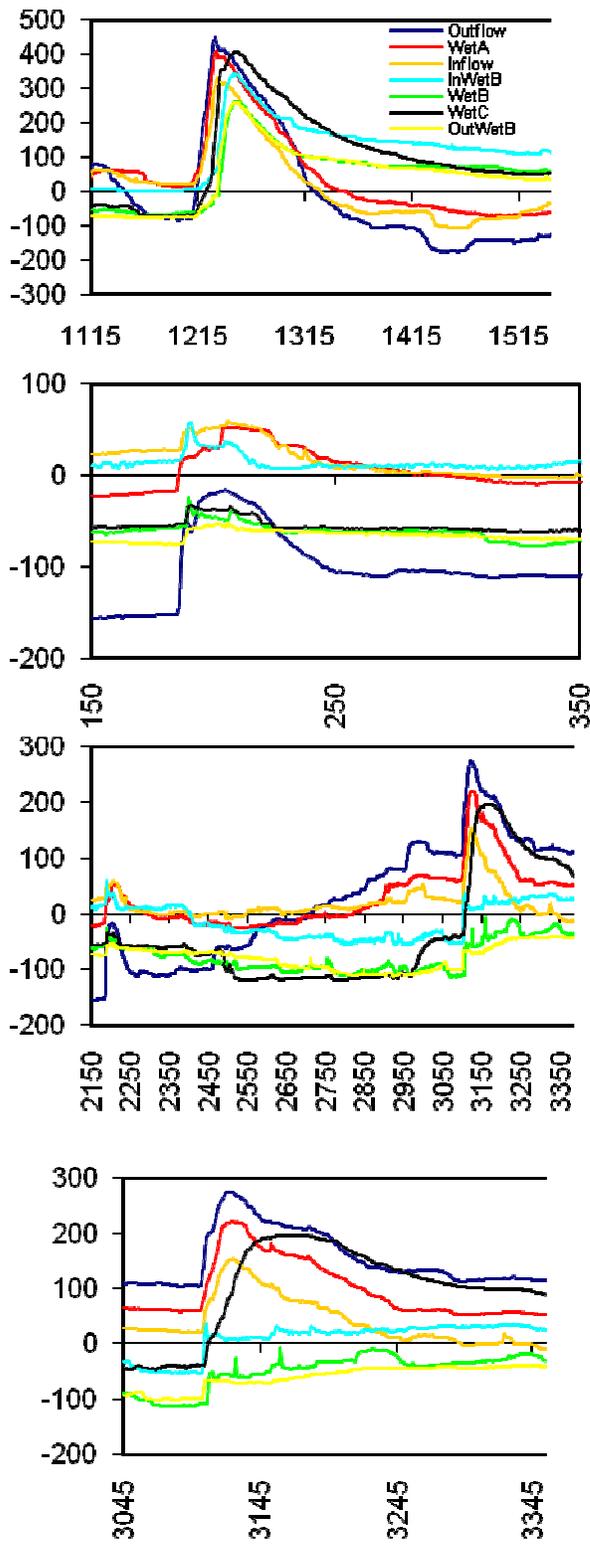


Figure 6.

Streamflow standards for streams of the Hudson River Valley and New York

Basic Information

Title:	Streamflow standards for streams of the Hudson River Valley and New York
Project Number:	2010NY136B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	22
Research Category:	Climate and Hydrologic Processes
Focus Category:	Drought, Water Supply, None
Descriptors:	None
Principal Investigators:	Mark Bain

Publications

There are no publications.

Streamflow standards for streams of the Hudson River Valley and New York

Mark Bain, Natural Resources, Cornell University

Problem and Research Objectives

The New York State Department of Environmental Conservation (NYDEC), Division of Water is working now to better specify a streamflow standard for regulating water withdrawals. Measurable standards are needed for important environmental management decisions, and some pressing water use issues facing New York now. The most notable case at this time is the gas drilling in the Marcellus Shale using high-volume hydraulic fracturing. The Marcellus Shale case demonstrates that numeric standards will be needed, and available standards were selected from other geographic locations. This study aims to recommend numeric streamflow standard for New York that will be technically sound, updated, and relevant for New York.

How much water does a stream need? This question has been challenging research and regulatory activities for almost a half century. Many influential papers have made the case that water is needed for stream and river conservation without saying how much. Thus, when water withdrawals are proposed, streamflow needs are set on a case by case basis, and the analyses are debated and contested for the specific situation. Nevertheless, clear and quantitative standards for streamflow can be valuable for many environmental decisions like water use constraints on the Marcellus Shale gas development. Standards provide a basis for judging acceptability, have a pass or fail outcome, set a performance target for project designs, and set the context for water users. New York like almost all governments will retain a generalized streamflow standards to allow case by case decisions.

My goal is to provide a clear and justified instream flow standards for use in New York. I will provide two sets of standards with annual specifications in proportional units (% of average discharge) and drainage area coefficients ($\text{m}^3/\text{s}/\text{km}^2$ drainage area). The specific objectives are to:

1. Synthesize flow depletion impacts – Using worldwide reports of stream alterations and their consequences, organize effects on a scale of stream ecosystem alteration magnitude.
2. Derive a standard using proportions – Using scaled impacts associated with flow reductions specify limits as a proportion (%) of natural streamflow.
3. Specify base flow standards – Apply the same analyses used in New England to calculate streamflow standards for New York in discharge volume per drainage area.

Methods and Procedures

A thorough search will be conducted for reports and published studies of impacts from streamflow reductions where specific information is reported on water withdrawals, streamflows, and effects on aquatic and river dependent organisms. Cases will not be used where non-flow effects (e.g., thermal alteration, sediment and channel changes, water quality) were the dominant reason for impacts on river ecology. The data extracted from the literature review will provide a comprehensive set of observations on streamflow changes and ecological impacts. The EPA developed biological condition gradient will provide a method to organize incommensurate ecological changes into a common scale of impact magnitude. This scale spans undisturbed or natural ecosystem status to severely altered environments with major loss of ecosystem structure and function. We analyzed the flow characteristics associated with substantial degradation of stream ecosystems. The outcome of this task will be a data set in an organized by impact magnitude that will provide a basis for relating the streamflow reductions and ecosystem quality.

The data set of streamflow reduction and ecosystem impact magnitudes will be used to define a standard for streamflow maintenance as a percent average discharge reduction on a monthly or seasonal basis. Extrapolation of streamflow standards from an ecosystem condition gradient is new, but more rigorous and defensible on technical grounds. These analyses and derivation of proportional streamflow reduction standards will be based on recent ecosystem theory and results from decades of study of flow altered streams.

My second type of streamflow standard places limits on streamflows on a per drainage area basis: cubic meters per second for each square kilometer ($m^3/s/km^2$) of drainage area. These values (runoff rates) can also be stated in monthly or seasonal terms to maintain an appropriate flow regime. The most common set of standards of this type were posed by the US Fish and Wildlife Service based on an analyses of New England rivers and their general ecological status. The terms used are the New England base flow policy or aquatic base flows. The NYDEC applied the New England base flow values in the Marcellus Shale environmental impact statement without adjustment to the climate and hydrology of the region. I will conduct a new analysis of the type done by the US Fish and Wildlife Service in New England using stream quality data of NYDEC and streamflow data from the US Geological Survey (USGS, gage records). The NYDEC Division of Water, Stream Biomonitoring Unit, has been assembling stream quality for more than 30 years and the results are available. These data will be used to identify stream quality that can be paired with USGS gage data to relate streamflows per drainage area with stream ecological status. I can then calculate a set of New York aquatic base flows that will serve as a set streamflow standards for application in New York.

Principle Findings and Significance

The data set we assembled relating streamflow reduction and ecosystem impact magnitudes using the biological condition gradient failed to show a consistent relation. Thus we cannot use this approach for defining a streamflow standard. Even though this procedure worked with some stream and river impacts, we found no clear relation we can use. Therefore, this approach did not work as expected.

As alternative to the biological condition gradient procedure, we reviewed many standards from countries, states, provinces, and regions have addressed water needs on a river basin scale by establishing a general standard for water needed to maintain acceptable riverine ecosystem conditions. This review is based on a reports different percentages of mean annual flow that support different categories of river condition overall. The general aim is to specify a minimum discharge or portion of surface water flow to meet environmental quality thresholds such as poor, fair, good, optimum, and others. The material analyzed provides estimates of water need for environmental support as a percentage of annual river flow, water availability, or original conditions. There are 11 estimates ranging from 30 to 78%. For application in this study, a set of standards using these results can be applied to overall water availability:

- < 30% for environmental needs results in significant environmental losses
- 30-50% for environmental needs is likely to result in marginal environmental conditions
- >50-80% for environmental needs will likely maintain good environmental conditions
- >80% for environmental needs is likely to result in excellent environmental conditions

We conducted an analyses using the New England base flow procedure and it showed consistent streamflow for streams and rivers in the Hudson valley, western and central New York, and northern New York. The analyses is complete but has to be reviewed and finalized before stating the streamflow standards.

This summer when Mark Bain returns to full time campus work after he completes is sabbatical leave he will issue a more details report to the Hudson River Estuary Program and the New York State Water Resources Institute. This will complete the project fully and set clear guidance for streamflow conservation needs.

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Publications and conference proceedings: none.

Students and researchers engaged: Two post-BS Cornell graduates, and 1 post-MS graduate.

Any additional grants: Collaborations with Hudson River Estuary Program that will build on this work.

The New York State Master Watershed Steward Program: Building Capacity for

Basic Information

Title:	The New York State Master Watershed Steward Program: Building Capacity for
Project Number:	2010NY137B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	22
Research Category:	Social Sciences
Focus Category:	Education, Management and Planning, Non Point Pollution
Descriptors:	None
Principal Investigators:	Shorna Broussard Allred

Publications

There are no publications.

Characterization of Attitudes among Hudson River Estuary Watershed Municipal Officials about Climate Change Adaptation

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Problem Statement:

New Yorkers are already observing the effects of global climate change in their surroundings, including documented increases in precipitation, warmer springs and earlier river thaws, and changes in plant phenology. Additionally, New York is a climate change leader at the state level with the New York State Climate Action Plan Interim Report focused on the goal of reducing GHG emissions 80% by 2050. Several Cornell faculty have played an important role in the development of the new state climate plan, and in the recent NYSERDA-funded assessment of climate change adaptation strategies. There is a need to translate the technical findings of these reports into easily understandable and locally relevant documents to help local officials with long-term decision-making. As a home rule state, New York has a large number of small local governments (62 counties, 932 towns, and 62 cities), and many decisions that affect energy, infrastructure and land use are made at the local level. Mitigation of, and adaptation to, climate change will create unprecedented challenges for municipal officials in New York. Preparing them to take advantage of opportunities and minimize the adverse consequences of climate change will require improved education and outreach to diverse audiences and new decision-makers.

The Hudson Valley region has also been a leader in climate change, much due to the leadership of the DEC's Hudson River Estuary Program and formation of a Hudson River Climate Change Network. As of late 2010, 37 communities had signed onto the DEC's Climate Smart Communities pledge and have begun working on climate change at the local level.

Several Cornell faculty have played an important role in the development of the governor's new draft Climate Action Plan, and in the recent NYSERDA-funded assessment of climate change adaptation strategies. However while this represents movement in the right direction, there is a need to involve more communities, especially those with increased vulnerability to shoreline changes and flooding. There is also a need to increase understanding of municipal official's climate change awareness and ability to take action at a local level, and to provide them with locally-relevant information and decision-making tools.

The overall project objectives are to 1) review and summarize recent studies on conditions and motivation for effective local action to address climate change mitigation and adaptation, including the role of State programs, ICLEI, the Climate Smart Registry and the NYS Climate Smart Communities Pledge, among others; 2) conduct a quantitative survey, and follow-up in-depth interviews, with local government officials in the Hudson Valley, and 3) explore the rationale and extent to which local governments are taking action to address climate change, and the most effective means of reaching municipal officials. The survey and in-depth interviews will also explore obstacles to local action and the interaction of local efforts with state and federal climate change policies. The survey results will offer insights regarding the benefits, limitations, and strategies for local climate change adaptation policies. The specific objectives are below:

Project Objectives:

1. Determine Hudson Valley local government officials' attitudes toward climate change (specifically those in shoreline communities);
2. Understand municipal officials roles and responsibilities, and perceptions of climate change taking place in their communities;
3. Determine local government officials' views of risks, vulnerabilities, and issues associated with climate change as it will impact the natural resources and infrastructure under their jurisdiction;
4. Examine if and why (or why not) local governments are taking action to mitigate and adapt to climate change;
5. Determine local government officials' views of adaptations and policy options which might address issues resulting from climate change.
6. Determine the most effective ways of reaching municipal officials with information about climate change threats at a local level – including the resources that will help local government officials implement solutions and adaptations.

Methods and Procedures:

The primary research methods in this project include a quantitative survey of municipal officials in New York and the Hudson Valley and qualitative in-depth interviews with a subset of municipal officials. The PI and Co-PI received a Cornell Smith Lever grant to develop and pre-test a quantitative survey instrument that is currently being implemented statewide with municipal officials in New York (N=1,416). The criteria for selection of municipal officials from a diverse cross-section of the Hudson Valley to conduct in-depth interviews with include: 1) municipalities that have experienced extreme weather events related to climate change, 2) municipalities that have adopted the NYS Climate Smart Communities Pledge, and 3) those municipalities that have not taken actions related to planning for climate change.

Due to the delay in WRI funding, the start date of the project was delayed. We have developed the semi-structured interview guide and are scheduling interviews. The in depth interviews will be completed by the summer of 2011, recorded and transcribed, and the results will be compared to results of the statewide survey. Both the survey and interviews will help

researchers understand more about the knowledge base, information needs, level of local action to date, barriers to action, and motivations of local municipal officials in addressing climate change, particularly climate adaptation. We will use the research results to develop a municipal official's toolkit that will include municipal official video clips from interviews about changes they are already seeing in their communities, annotated presentations and webinars and accompanying fact-sheets). We will utilize interviewees' feedback and input in the development and design of the draft toolkit.

Principle Findings and Significance:

This study is significant because there is increased attention in the environmental politics/policy literature of the importance of local actions to address climate change in the absence of federal regulation in the US, but little data exists to document the motivations, barriers of successes of these actions. The few studies of local climate change action also focus mostly on state actions to mitigate climate change, while there is less focus on climate change adaptation efforts at the local level.¹ While the findings of this study will provide data on local climate change action in New York State, with a case study focus on the Hudson Valley region, that has been a leader in the state on regional climate change action, the insights will be relevant beyond the region. We do not have any publications yet but plan to present draft findings at future environmental policy-related conference (APSA) focusing on the growing importance, role and success of local actions to address climate change in the absence of federal regulation in the US. In the 2nd year of the project we will publish the results in an environmental policy-related peer-reviewed journal.

Additionally, this work also leverages a \$60,000 Smith-Lever grant (S. Broussard Allred Co-PI) aimed at climate change needs assessment and education for natural resource professionals and municipal officials. A Cornell University undergraduate research assistant will be employed for the summer of 2011 to support this project.

¹ See for example, Engel, Kirsten (2006). State and Local Climate Change Initiatives: What Is Motivating State and Local Governments to Address a Global Problem and What Does This Say about Federalism and Environmental Law; 38 Urb. Law. 1015; or Betsill, Michele M. (2001). Mitigating Climate Change in US Cities: Opportunities and obstacles, in Local Environment: The International Journal of Justice and Sustainability Vol 6, Issue 4, 2001, p. 393 – 406.

Quantifying the endocrine activating potential of New York State waters using steroid-responsive bioassays.

Quantifying the endocrine activating potential of New York State waters using steroid-responsive bioassays.

Basic Information

Title:	Quantifying the endocrine activating potential of New York State waters using steroid-responsive bioassays.
Project Number:	2010NY138B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	22
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Toxic Substances, None
Descriptors:	None
Principal Investigators:	Anthony Hay

Publications

There are no publications.

Objective. We quantified the amount of endocrine-active compounds in New York State waters and waste water treatment plant effluents. Specifically, we screened extracts of these waters for their potential to induce the expression of genes whose transcription is responsive to estrogen, androgen, progesterone, and glucocorticoids in mammalian cells.

Every day humans release hundreds of biologically active compounds including pharmaceuticals into receiving waters. Many of these compounds can interact with nuclear hormone receptors in humans and act to perturb the endocrine system from its normal state, yet we know surprisingly little about what endocrine-active chemicals are present in our waters and if they pose a risk to humans or wildlife. Although significant advances have been made in analytical chemistry which permit the detection of very low concentrations of chemicals (ng/L or parts per trillion in some cases), chemists typically need to know something about the structure of these compounds and have reference standards for them in order to unambiguously confirm their presence in environmental samples. In some cases abiotic and/or biological modification can change the structure and behavior of these compounds enough that they escape analytical detection even though their biological activity may remain. More information is needed regarding the endocrine-active chemical burden in New York State waters before we can fully characterize the risks they pose to human and environmental health. We used a series of steroid responsive bioassays to do a preliminary assessment of the endocrine-active compounds in selected New York State waters. Specifically, we worked with our collaborators at Biological Detection Systems Inc. (BDS) in the Netherlands to assay water for the presence of compounds that activate nuclear hormone receptors for estrogen, androgen, progesterone, and glucocorticoids using the CALUX bioreporters they developed (Van der Linden et al. 2008). This work is important because everyone is concerned about having clean water for themselves and the environment. The public wants to know what is in their water and if it is harmful. WWTP operators need to know what is getting by them before they can figure out what needs to be done to stop it. Regulators and risk assessors need to know what levels of endocrine-active compounds are in our waters before a complete risk assessment can be done and before we can determine what steps need to be taken to further address the issue of endocrine-active compounds in our water.

Methods

Water collection and extraction

Water samples were collected in glass bottles that had been pre-rinsed with ultra clean hexane prior to use. The samples were immediately placed on ice and stored at 4⁰C for a maximum of 5 days. Following water collection, 1000 ml was filtered, 500ml of which was extracted three times with 50 ml of ethyl acetate using a pre-cleaned separatory funnel. The combined ethyl acetate extracts were evaporated and taken up in 80 µl of dimethylsulfoxide (DMSO). To ensure that no contamination occurred during this sample preparation stage, we also processed a control consisting of ultrapure distilled deionized water. In addition we also sent BDS a DMSO blank as a control. Samples were not allowed to come into contact with any plastics in order to prevent possible contamination with plasticizers that are known to have estrogenic activity.

CALUX bioassay analysis

CALUX bioassays for the estrogenic, androgenic, progestagenic, and glucocorticoid hormonal content of water extracts were carried out as described by van der Linden et al. (2008). Briefly, U2OS human cells with a HRE-Luc gene were seeded into 96 wells plates with DF medium (w/o phenol red and supplemented with DCC stripped serum). After 24 hours of incubation (37°C, 7.5% CO₂), the medium was replaced by medium containing sample extracts (max. 0.4% DMSO) for activity testing. After 24 hours of exposure, the medium was removed and the cells were lysed in 30 µL Triton lysis buffer. The addition of the appropriate substrate (luciferin) then caused light to be emitted and the amount of light was quantified using a luminometer (Lucy 2, Anthos, Austria). The amount of light produced is proportional to the amount of ligand-ER or AR binding, which is related to hormone equivalents, e.g. estradiol or DHT equivalents (EEQs or DHT-EQ) in the original water samples. On all plates, a dose-response curve of the corresponding reference compounds was included for adequate quantification of the response. In this way, the CALUX assay allowed us to report toxic equivalents benchmarked against known endocrine-active compounds e.g. estradiol or DHT. To rule out any confounding influences due to toxicity of the water extracts, cells were monitored for signs of cytotoxicity by means of light microscopy.

Results

We analyzed a total of 19 water samples from multiple New York State locations at different times of the year for the presence of four classes of endocrine-active chemicals (estrogens, androgens, progesterones, and glucocorticoids). Since compounds that mimic the effects of natural endocrine-active chemicals (agonists) have been found to be more abundant than those that inhibit the effects of natural endocrine-active chemicals (antagonists) (van der Linden et al 2008), and because of budget limitations, we only tested for agonists.

As shown in Figure 1, solvent extracts from all Hudson River samples induced estrogenic responses, ranging from 0.094-0.701 ng E2 Eq/L, with the maximum response coming from the winter Schodack Island sample. Both of the extracts from Piermont Pier induced progestogenic

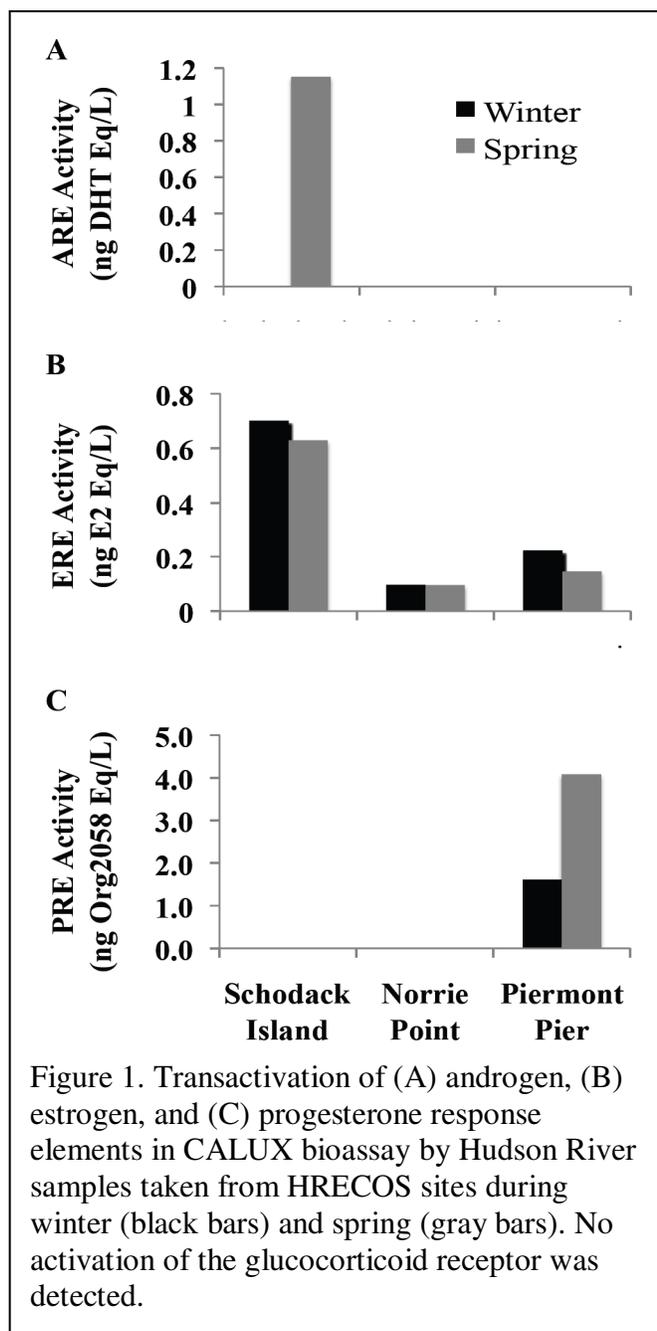


Figure 1. Transactivation of (A) androgen, (B) estrogen, and (C) progesterone response elements in CALUX bioassay by Hudson River samples taken from HRECOS sites during winter (black bars) and spring (gray bars). No activation of the glucocorticoid receptor was detected.

responses ranging from 1.6-4.08 ng Org2058 Eq/L. The extract from the spring Schodack Island sample induced an androgenic response of 1.15 ng DHT Eq/L. No glucocorticoid responses were observed. These CALUX results are consistent with those reported for surface waters in the Netherlands (0.18-0.5 ng E2 Eq/L, n.d.-4.5 ng Org2058 Eq/L, 0.39-1.3 ng Dex Eq/L, and n.d.-12 ng DHT Eq/L) (Van der Linden et al., 2008).

The androgenic and estrogenic activities at our field sites were lower than, but within one order of magnitude of activity levels associated with endocrine disruption in the field. For example, female mosquitofish (*Gambusia holbrooki*) were found to be masculinized in a Florida river impacted by a pulp paper mill, where river water androgen activity levels were 6 ng DHT Eq/L (Jenkins et al., 2001). Feminizing effects, including skewed sex ratios, elevated vitellogenin production in males, impaired gonadal development, and reduced fertility are commonly reported for aquatic species living in waters heavily impacted by WWTP effluents (Bjerregaard et al., 2006; Jobling et al., 1998, 2002, 2009; Vajda et al., 2008). For example, streams in the United Kingdom that had greater than 1 ng E2 Eq/L also had roach (*Rutilus rutilus*) populations with modified sex ratios (Jobling et al., 2006, 2009). In another study, a Canadian lake dosed with 5-6 ng 17 α -ethynylestradiol/L caused feminization followed by near extinction of the fathead minnow (*Pimephales promelas*), along with impaired gonadal development and reduced hatching success of anurans (*Rana spp.*) (Kidd et al., 2007; Park and Kidd, 2005). Thus, while we do not have specific information on the chemical species responsible for the endocrine activity measured using the CALUX assay, our results suggest that current levels of endocrine activity in Hudson River waters may have biological significance.

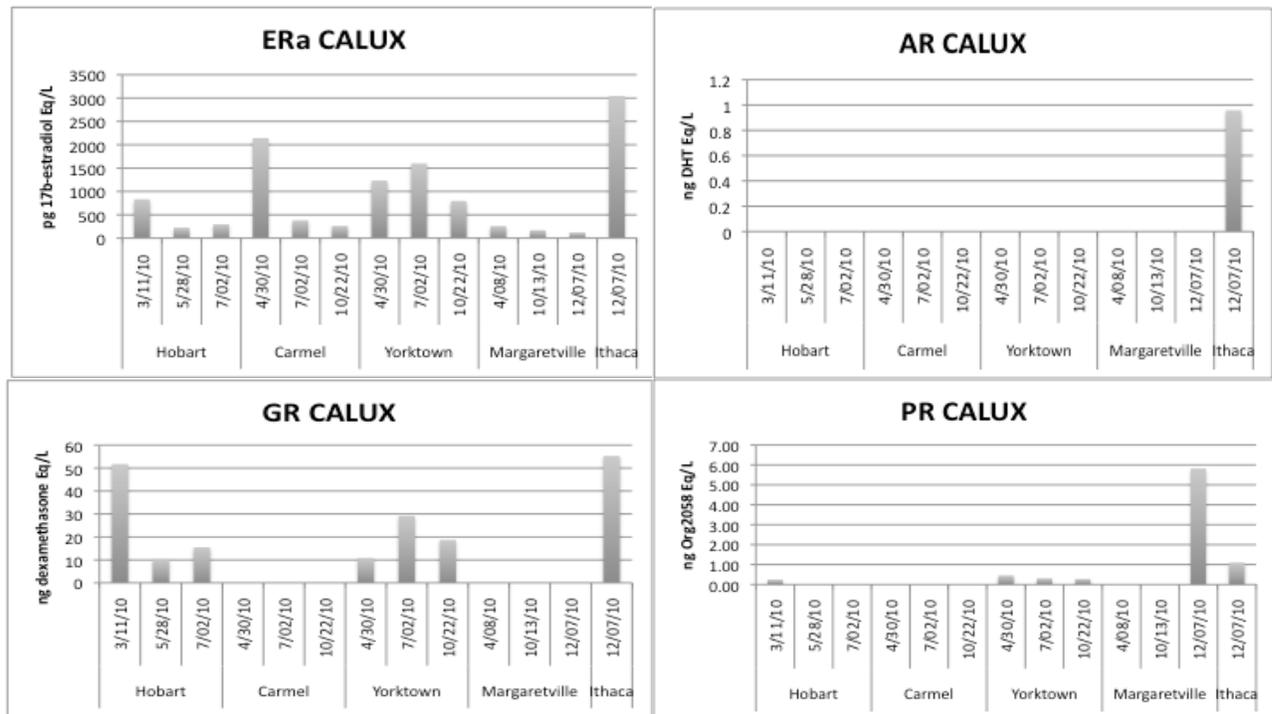


Figure 2. Endocrine disrupting activities in wastewater treatment plant effluents from New York State. Estrogen response (Era), Androgen response (AR), Progesterone response (PR), and glucocorticoid response (GR).

With respect to the waste water treatment effluent samples whose results are presented in Figure 2, it is surprising that the Ithaca WWTP effluent induced the highest responses for all reporters except for PR. Only one sample was taken from the Ithaca WWTP so it is not clear how consistent this response might be. It is possible (but unlikely) that the sample could have been contaminated at the time of acquisition; however, it is less likely that the conditions during sample extraction affected the results, as the 12/07/10 Margaretville sample was extracted at the same time. The levels of endocrine activity detected in these samples is of a similar order of magnitude to those detected in Dutch waste water treatment effluents by van der Linden *et al.* (2008), although Ithaca's ER activity was more than 3 times higher and Margaretville's PR activity was more than 7 times higher than in the Dutch samples (0.39-1 ng estradiol equivalents/L and 0.78-0.86 ng Org2058/L respectively). The data on the wastewater effluent samples also has matching GC/MS measurements and we will begin writing that manuscript shortly as soon as we receive that data from our USGS collaborators. We will then place these numbers in a risk based context as was done for the HRECOS data.

Manuscript In Preparation

We have prepared a manuscript comparing the CALUX bioassay results with chemical measurements (GC/MS) made on the HRECOS samples and are in the process of clearing that manuscript through internal USGS review before submitting it for publication.

Student Support

This grant helped to support the dissertation research of Ms. Amy Risen, a Ph.D candidate in Environmental Toxicology at Cornell University.

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Information Transfer Program Introduction

None.

Director's Office Information Transfer

Basic Information

Title:	Director's Office Information Transfer
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End Date:	2/28/2011
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Congressional District:	22
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Focus Category:	None, None, None
Descriptors:	None
Principal Investigators:	Susan Riha, Stephen Shaw

Publications

1. Riha, S.J.; Rahm, B.G. Framework for assessing water resource impacts from shale gas drilling NYWEA Clear Waters. 2010, 40 (Winter), 16-19.
2. Rahm, B.G.; Riha, S. Framework for Assessing Water Resource Impacts from Shale Gas Drilling Green Choices, website of Cornell University's Department of City and Regional Planning, December, 2010.

Title: Director's Office, Information Transfer Workplan

The Director and staff of the NYS Water Resources Institute undertake public service and partnership activities. Most are conducted through multidisciplinary projects funded outside the Water Resources Research Act (WRRRA) context. In order to couple WRRRA activities to other NYS WRI activities, a portion of WRRRA resources are devoted to information transfer through a partnership program with the Hudson River Estuary Program, dissemination of information related to emerging issues, and student training.

Hudson River Estuary Program Partnership

Funded by the NYS Department of Environmental Conservation (DEC), the program is guided by 12 goals as part of its Action Plan formed in 1996. These goals address signature fisheries, river and shoreline habitats, plants and animals, streams and tributaries in the entire watershed, landscape and scenery, public access, education, waterfront revitalization, water quality, and partnerships and progress. WRI and DEC work together to protect this rich estuary ecosystem that is a source of municipal drinking water, spawning grounds for migratory fish, habitat for bald eagles, and an excellent recreation area for boaters, anglers and swimmers.

Marcellus Shale

The NYS WRI director and staff continued to act as an objective information source in the contentious debate over the impacts of Marcellus Shale drilling in New York State. Some of this educational transfer was informal. WRI maintained a website with information on drilling and links to other credible sources. The WRI director as fielded numerous phone calls and information requests from the media, public officials, and other interest groups.

The NYS WRI also undertook several more formal information transfer activities, including the writing of policy articles for state environmental conservation publications, acting as panelists for public information sessions, and speaking at public seminars. A list of such information transfer efforts is included below:

Rahm, B.G.; Riha, S. "Framework for Assessing Water Resource Impacts from Shale Gas Drilling" [Green Choices](#), website of Cornell University's Department of City and Regional Planning, December, 2010

Rahm, B.G. "Interaction between Development & Water Treatment Systems" Class lecture in Landscape Architecture Department, Cornell University. Ithaca, NY. November 29, 2010

Rahm, B.G. "Monitoring for Water Resource Impacts: Risks & Science" Webinar, The Paleontological Research Institution. Ithaca, NY. November 17, 2010

Rahm, B.G. "Monitoring for Water Resource Impacts of Marcellus Shale Gas Development" Energy Transitions and the New York Landscape Colloquium. Invited Talk. Cornell University. Ithaca, NY. November 3, 2010

Rahm, B.G. "Fracking/Fracturing: Gas is Good?!" Invited Talk. Hubert H Humphrey Fellows, Cornell University. Ithaca, NY. October 15, 2010

Rahm, B.G. "De l'eau dans le gaz – Partie 3" **Radio-Canada**, interviewee for radio broadcast on shale-gas, September 19, 2010.

Riha, S.J.; Rahm, B.G. "Framework for assessing water resource impacts from shale gas drilling" *NYWEA Clear Waters*. 2010, 40 (Winter), 16-19.

Riha, S.J. "The Science of Hydrofracking". WRVO Radio Community Forum. SUNY Oswego Metrocenter in Syracuse. June 2010.

Riha, S.J. "A Community Conversation: Gas Drilling and Water Safety". WSKG Radio. Vestal, NY. June 15, 2010.

Riha, S.J. Interviewed for "Natural gas supply, jobs and technique debate booming". USA Today, news article published April 28, 2010.

Shaw, S.B. "Unraveling the Water-Energy Nexus in New York State". Invited Talk. Cornell Cooperative Extension In-Service Conference. Ithaca, NY. 11/17/2010.

Shaw, S.B. "Impacts of Shale Gas Extraction on Water Resources in New York". Invited Talk. NY Water Environment Association – Central and Genesee Valley Chapter. Ithaca, NY. 10/29/2010.

Shaw, S.B. "Translating global climatology to local hydrology: Are we more uncertain than we are willing to admit?". Invited Talk. Department of Horticulture, Cornell University. Ithaca, NY. 9/27/2010.

Shaw, S.B. "Climate Change and New York's Water Resources". NOAA/ Sea Grant Climate Change Literacy Workshop. Ithaca, NY. 8/4/2010.

Shaw, S.B. "Impacts of Shale Gas Extraction on Water Resources in New York". Invited Talk. Finger Lakes Water Works Conference. Watkins Glen, NY. 4/1/2010.

Student Public Service Activities

Students and interns are supported in several ways through WRI:

- Competitive Grants Program – in many cases, grants provide for at least one graduate or undergraduate student to work under faculty supervision on priority problems in New York State;
- Hudson River Estuary Program – internships are sought through the Student Conservation Association each year for at least one graduate, undergraduate or high school student to work with WRI staff.
- Direct support of student research – WRI staff also directly support undergraduate research by acting as mentors to undergraduates doing research as part of independent study projects. This past summer

and fall, WRI had two students working on projects, one related to Marcellus Shale (I. Arginteanu) and another related to climate change impacts on crop yields (H. Knowlton).

USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	11	0	0	0	11
Masters	2	0	0	0	2
Ph.D.	1	0	0	0	1
Post-Doc.	0	0	0	0	0
Total	14	0	0	0	14

Notable Awards and Achievements